

# DEC STD 070-9 Video and Printer Systems Reference Manual - Sixel Graphics Extension

**DOCUMENT IDENTIFIER:** A-DS-EL00070-09-0000 Rev A1, 03-Aug-1990

**ABSTRACT:** This section describes the Sixel Graphics Protocol, which forms an extension to the Level 1, Level 2, and Level 3 Character Cell Display service class. Sixel Graphics provide a means of encoding and displaying raster binary data on raster devices of various capabilities.

**APPLICABILITY:** SARA Formal Cross-Component Standard. Mandatory for Engineers designing hardware for terminal products and Software Engineers designing programs using terminal interfaces.

**STATUS:** APPROVED 03-Aug-1990; use VTX SMC for current status.

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DOCUMENT IDENTIFIER: A-DS-EL00070-09-0000 Rev A1, 03-Aug-1990

REVISION HISTORY:                      Rev A,                      24-Nov-1987  
                                                 Rev A1,                      03-Aug-1990                      ECO Number CTS01

Document Management Category:                      Terminal Interface Architecture (STI)  
Responsible Department:                      VIPS Architecture Group  
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APPROVAL: This document, maintained by the VIPS Architecture Group, has been reviewed and recommended for approval by the General Review group for its category for use throughout Digital.

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## 1 INTRODUCTION

This document defines a method of defining and transmitting encoded bit map data over a communication line known as the Sixel protocol. All or portions of this protocol may be stored in files. This protocol is to be used in display devices (video and hardcopy) of various imaging (drawing) capabilities.

In addition, it defines the relationship of this protocol to the ANSI Text presentation protocol. While the Sixel protocol is not intended to be a part of the ANSI text protocol, there are certain interdependencies.

This document regroups several extensions made to the "Sixel Protocol", the original 7-bit black and white protocol (LA34/VK100), the 8-bit extension (LA100-V2), the variable aspect ratio extension (LA100-V2), the color extension (VT240), and finally a limited support for software-handled viewporting.

### 1.1 OVERVIEW

The transmission of bit map data is one way of transferring visual information. It is required for natural images (pictures usually generated by scanning an original), or as a low level protocol for interfacing devices supporting different protocols, or when composition time is long compared to transmission time.

The Sixel protocol allows devices to receive and print black and white or color bitmap data at various sizes over a stream-oriented communications line. Six bits of each 7-bit or 8-bit character code are used to represent bit map data, allowing the remaining values to be used to control the context of the communications line and to fit within the ANSI text syntax.

The areas of interest when considering this protocol are:

1. Defining the data, at a given quality level, with all attributes. Ensuring that an imaging device having the same capabilities as the generating device will produce an identical picture.
2. Positioning the data
3. Defaulting mechanisms when some data cannot be exactly reproduced, or some command cannot be executed.

The structure of the protocol is intended to support a layered system approach, where there are several independent processes that define or interpret portions of the total data. For example, this allows the size of an image to be defined independent of the actual image definition. This implied scaling of bit map data is difficult to implement exactly and realizations will vary from device to device.

The Sixel protocol allows considerable freedom in specifying the value and size of the bit data to be displayed. It is expected that most imaging devices implementing this protocol will not be able to image the bit map data exactly as specified for all possible parameter values. This limitation is usually due to device imaging resolutions, dot sizes and computational limitations. The common fallback will be for devices to image at integer multiples of the device resolution, but this standard does not prohibit more creative solutions. See the section on imaging fallbacks for the definition of proper fallbacks.

## 2 GOALS OF THE SIXEL PROTOCOL

1. Provide a general purpose image data input for display devices.
2. Be syntactically compatible with ISO 2022 code definition, and further to be compatible with ANSI X3.64 and ISO 6429. This supports the requirement that the protocol be transmittable on 7-bit stream-oriented serial lines, including control code (X-ON, X-OFF) flow control.
3. Support screen size images from VT125, VT24X terminals. This size is 768 pixels by 240 pixels for the VT125 and 800 pixels by 240 pixels for the VT24X series. Both printed at a 2:1 pixel aspect ratio.

It is a goal that any pixel value combination for rasters of this size be printable by conforming devices. In other words, 'picture too complex' for the above raster sizes is not permitted.

The protocol should support any size rasters, although not all devices will be capable of displaying them.

4. It is a goal that it be possible to relate the size and placement of the raster to the ANSI text coordinate space, but not that the individual pixels relate to the ANSI text coordinate system or characters. It is not a goal to allow modification to the rendition of characters imaged via ANSI text with pixels imaged via the Sixel protocol.
5. It is a goal to allow independent control over the pixel definitions (shape and value of pixels) and the imaged size of the pixels.
6. It is a goal to be compatible with previous devices supporting limited Sixel printing - LA34, LA12, LA100, VT125, VT240.

## 3 TERMINOLOGY

**Dot** - The smallest displayable unit; a light dot on a screen, an ink dot on the paper. Dots can be round, oval, square, rectangular, small or big.

**Pixel** - The logical rectangular image area defined by each bit of Sixel data as intended by the generation software. The shape of a pixel is defined by an aspect ratio, and has no size.

**Pixel Aspect Ratio** - Defines the shape of the pixel as a ratio of the vertical side of the rectangle and the horizontal side. For example, a square pixel has an aspect ratio of 1 to 1 (or 10 to 10) and a pixel twice as high as wide has an aspect ratio of 2 to 1 (or 20 to 10).

**Pixel-Spot** - The area that is actually imaged (printed) for each pixel. It has a shape (Round, oval, square..) and a size. The shape and size are totally device dependent, and may or may not be related to the grid size.

**Grid** - The positions on the display, where pixel-spots may be placed. These positions are dimensionless points, even though the pixel spots do have some size which may even exceed the grid size. The horizontal distance between the two positions is defined by the horizontal grid size parameter. The vertical distance between two positions is defined by the horizontal grid size parameter and the aspect ratio parameter.

The distance between two positions can be bigger or smaller than the pixel-spot size. This relation is totally defined by the device, and may vary from device to device, and vary on the same device from one set of parameters to another.

The actual grid sizes available on the device may not match the exact grid size specification. In this case, the device will select a grid which best represents the specified grid. This 'best fit' grid is often called the 'actual grid' or 'actual grid size'. Note that most imaging operations deal with the actual grid and not the exact specified grid.

**Grid Size** - The distance between two adjacent grid points. The grid size may be different in the horizontal and vertical directions.

**Dot/Pixel/Pixel-Spot Relationship** - An imaging device may use several dots to represent a single pixel via a pixel-spot. Multiple dots can be used to cover an area larger than a dot size, or to produce some level of darkness, or to obtain some level of scaling.

**Raster** - All of the pixels used to define a single image. For purposes of this document, all of the pixels defined in a single Sixel control string.

**Raster Size** - The resultant size of the raster after it has been printed based on the actual grid size. When used in the context of pixels not yet printed, it is just the number of horizontal and vertical pixels of the raster.

**Overlap** - The percentage of the pixel-spot that is larger than the grid size. Overlap may be visually pleasing to smooth certain images, or may be used to cover device registration errors, or may be due to the device having a pixel-spot size more limited than the grid size.

**Sixel Active Position** - The Sixel active position is that position to which the next Sixel is to be printed. The actual Sixel is printed with a vertical offset to the Sixel active position so that machines which use the baseline of a character for positioning in ANSI text mode will be compatible with devices that position based on the ascender height of the character. This offset is in the vertical direction, the amount of 70 decipoints (.0972 inch). (See section - ANSI Text Interactions, While In Sixel Mode).

**Picture Definition** - This is all the data needed to describe the image, including colors, size, pixel aspect ratio, and encoded rasters (Sixel Data and Sixel Commands). It does not include formatting information such as position or actual presentation size.

**Sixel** - A Sixel is a group of 6 vertical pixels represented by 6 bits within a character code.

**Sixel Data** - This term includes only the encoded raster portion of the picture definitions.

**Sixel Commands** - These are commands included in the picture definition which provide additional information beyond the encoded raster, such as color, line breaking, etc.

## 4 LEVELS AND EXTENSIONS

While the Sixel protocol specification allows more device variations than the majority of the other SRM specifications, there are still several specific function sets that must be followed for compatibility. There are two levels and one extension defined for conforming devices. The levels are for variable grid size, while the extension is for color.

#### 4.1 LEVEL 1

Level 1 devices do not support the Set Raster Attribute command, Background Select, Horizontal Grid Size or Macro Parameter commands. Level 1 devices will parse these commands, but only print in one grid size. The level 1 grid size is that defined for Macro Parameter 1.

#### 4.2 LEVEL 2

Level 2 devices support everything a Level 1 device supports, plus the Set Raster Attribute command, Background Select, Horizontal Grid Size and Macro Parameter commands.

#### 4.3 EXTENSION - COLOR

Color is an extension to either level 1 or level 2 devices.

### 5 SIXEL PRINTING

Sixel printing consists of setting context and attributes for the pixels and then printing each Sixel in received order.

A Sixel is a group of 6 vertical pixels represented by 6 bits within a character code. A one value for a bit indicates that a pixel-spot will be placed at the corresponding grid position, a zero will cause the corresponding grid position to be unchanged (not written).

Upon entering Sixel mode, the current Sixel position is determined from the ANSI text position and is called the graphic left margin.

The Sixel active position is advanced to the next horizontal grid position as each Sixel is printed. Also, there are a few line control commands that modify the Sixel active position. Positioning is always relative to the Sixel active position, and can not go backwards except for returning to the graphic left margin via the graphic carriage return and next line commands.

The color of a pixel-spot is determined by the currently selected color in the color map, as specified with a color specifier control code. The color map is defined by optional parameters of the color specifier. Note that all 1 bits of a Sixel are imaged in the selected color. Therefore, if the image is to have pixels of different color that fall within a single Sixel, only those pixels of the current color should be set to a 1, and the line of Sixel data sent again with a new color selector and the appropriate 1 bits set for this color. A line of sixels must be sent (with a graphic carriage return between them), for each color that falls in the Sixel line.

Horizontal and vertical direction follow the ANSI text horizontal and vertical axes at the time Sixel mode was entered, with Sixel drawing always proceeding from left to right, top to bottom.

## 6 PROTOCOL STRUCTURE

The data and commands of the Sixel Graphics protocol can be conceptually separated into three primary fields:

1. Picture Definition - the body of the Sixel protocol which contains all the information needed to reproduce the image, regardless of size. The Picture Definition includes Sixel data and Sixel command codes. The Sixel data is the encoded image raster while the Sixel command codes control how the raster will be interpreted.

The picture definition is used by creation software, editing software, and imaging devices. It is intended that picture generating software will be able to create a file that contains the image definition independent of formatting information.

2. Formatting information - This data is added to the picture definition by the page composition software, defining the size of the picture data. The size is included in the Protocol Selector (see the example below) so that the parameters may be added without affecting the picture definition data.

In general, composition software need not interpret the picture definition data, although in certain cases it may need to determine the number of pixels in the picture definition by looking at the pixel extent parameters.

3. Positioning data - used by page composition software. The first pixel position is defined by the ANSI text active position at the time that the Sixel mode is entered. All other pixel positions are relative to the first based on the actual grid size and aspect ratio.

### 6.1 SIXEL CONTROL STRING

The formatting and picture definition for a Sixel graphic is contained in a Device Control String (DCS) envelope as defined in the "Code Extension" section of this standard, DEC STD 070-3.

DCS    Formatting Information    Picture Definition    ST

DCS (9/0) is the ANSI C1 control that begins a Device Control String (may also be coded as ESC P (1/11, 5/0) in 7-bits). The Formatting Information is represented by one or more Device Control String parameters separated by semicolons ";" (3/11) as defined by the code extension layer. The final character of the DCS Sequence is q (7/1) which identifies the Control String as containing Sixel data. The DCS parameters and final character together are called the Protocol Selector. The Picture Definition consists of Sixel data and commands as described in this standard. ST (9/12) is the ANSI C1 control that terminates a Device Control String (may also be coded as ESC \ (1/11, 5/12) in 7-bits).

### 6.1.1 Example Sixel Control String

```

ESC P  Ps1 ; Ps2 ; Pn3 q  " Pn4 ; Pn5 ; Pn6 ; Pn7 @@@@@@ ESC \
\____/  \_____/  \_____/  \____/  \____/
DCS    Protocol Selector    Raster Attributes    Picture    ST
                                command            data
                                \_____/  \_____/
                                Formatting    Picture Definition
                                Information

```

Where:

Ps1 Macro Parameter  
Selects from a list of fixed combinations for other parameters. Included for backward compatibility. New software should always specify this by 0 (zero).

Ps2 Background Select  
0 device default action  
1 no action (don't change zero value pixels)  
2 set zero value pixels to background color

Pn3 Horizontal Grid Size  
Given in units specified by ANSI SSU (default is decipoints, 1/720 inch).

q Final Character of DCS Introducer Sequence

" Sixel Control Code for Raster Attributes Command

Pn4 Pixel aspect ratio numerator  
(first parameter of Raster Attributes Command)

Pn5 Pixel aspect ratio denominator

Pn6 Horizontal Extent  
Number of pixels in image horizontally

Pn7 Vertical extent  
Number of pixels in image vertically  
(last parameter of Raster Attributes Command)

## 7 FORMATING INFORMATION

The formatting information currently consists of up to three parameters included in the Sixel DCS Introducer Sequence (Sixel Protocol Selector) by the page composition software. The following sections define each parameter of formatting information.

### 7.1 MACRO PARAMETER

The first parameter (Macro parameter) selects from a list of fixed combinations of values for other parameters in the Sixel data. This parameter exists for compatibility reasons and is to be set to zero in new software. New software is expected to define the three parameters explicitly. Explicit parameter definitions over-ride the macro settings. The following table defines the intent of the macro value:

| Macro value | Horizontal<br>Grid Size<br>(X .001") | Pixel Aspect Ratio<br>Vert pix : Horz pix |
|-------------|--------------------------------------|-------------------------------------------|
| 0 (default) | 7.5                                  | 200 : 100                                 |
| 1           | 7.5                                  | 200 : 100                                 |
| 2           | 3                                    | 450 : 100                                 |
| 3           | 4.5                                  | 300 : 100                                 |
| 4           | 6                                    | 250 : 100                                 |
| 5           | 7.5                                  | 200 : 100                                 |
| 6           | 9                                    | 150 : 100                                 |
| 7           | 10.5                                 | 130 : 100                                 |
| 8           | 12.0                                 | 112 : 100                                 |
| 9           | 13.5                                 | 100 : 100                                 |

The intended vertical grid size implied by the macro value is always 1/72 of an inch.

## 7.2 BACKGROUND SELECT

The second parameter (Background Select) specifies what is to be printed in grid positions not explicitly set to a one in the Sixel data. It is device dependent if the grid positions include all possible printable grid positions of the device, or only those grid positions within the horizontal and vertical extent parameters of the Set Raster Attribute command. Hardcopy devices will process this parameter as no action (as if parameter = 1).

The possible values for this parameter are:

- 0 device default action
- 1 no action (no change to zero bit value grid positions)
- 2 set to background color - zero bit value grid positions are set to the background color. The background color is device dependent.

## 7.3 HORIZONTAL GRID SIZE

The third parameter (Horizontal Grid Size) defines the horizontal grid size in units selected by the ANSI text Set Size Unit (SSU) command. This parameter, in conjunction with the pixel aspect ratio, defines the grid size.

If this parameter is zero or not present, the horizontal grid size is given by the macro parameter, otherwise, the horizontal grid size parameter overrides the macro parameter.

If the device does not implement the SSU command, the units will be the default value for the SSU command which is Decipoints (1/720 inch).

## 8 PICTURE DEFINITION

The Picture Definition consists of Sixel commands and Sixel data which describe a raster image. Sixel commands are coded as graphic characters in the range 2/1 to 3/14. Sixel data is coded as graphic characters in the range 3/15 to 7/14.

## 8.1 SIXEL COMMANDS

Sixel commands are used to control how the image raster is interpreted, and may be embedded anywhere in the picture definition.

A Sixel Command consists of a code in the range 2/1 through 3/14 (except parameters and parameter separators) which identifies the command, followed by zero or more parameters separated by parameter separators. Each parameter is formed by one or more consecutive decimal digits 0 through 9 (3/0 through 3/9). Commands having more than one parameter must use the parameter separator ; (3/11) between parameters. A Sixel command is terminated by any non parameter code, that is, any code other than 3/0 through 3/9 (parameter digits 0-9) or 3/11 (parameter separator ;). Note Format Effectors (0/8 to 0/13) and SPACE (2/0) are ignored within sixel control strings (see coding section).

The following list summarizes the currently defined Sixel Commands and their coding. Sixel Commands that are not recognized by the device must be parsed and ignored.

| Code                          | Command                                                                                                                                                                                                                                                           |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ! (2/1)                       | Repeat Introducer<br>1st parameter - repeat count                                                                                                                                                                                                                 |
| " (2/2)                       | Set Raster Attributes<br>1st parameter - Pixel aspect ratio numerator<br>(relative height)<br>2nd parameter - Pixel aspect ratio denominator<br>(relative width)<br>3rd parameter - Horizontal Extent<br>4th parameter - Vertical Extent                          |
| # (2/3)                       | Color Introducer<br>1st parameter - color number<br>(others optional)<br>2nd parameter - color coordinate system<br>3rd parameter - Hue angle, 0-360 Red, 0-100<br>4th parameter - Lightness, 0-100 Green, 0-100<br>5th parameter - Saturation, 0-100 Blue, 0-100 |
| \$ (2/4)                      | Graphics Carriage Return                                                                                                                                                                                                                                          |
| - (2/13)                      | Graphics Next Line                                                                                                                                                                                                                                                |
| ; (3/11)                      | Parameter Separator                                                                                                                                                                                                                                               |
| 0 through 9 (3/0 through 3/9) | Parameter digits                                                                                                                                                                                                                                                  |

### 8.1.1 Repeat Introducer

The Repeat Introducer command allows sixels to be run-length encoded by specifying a repeat count before a sixel. The repeat introducer is followed by a numeric value which indicates the number of times the next sixel is to be repeated. A repeat count of zero implies a repeat count of 1. The maximum value for the repeat count is 32767. If no sixel data character follows the repeat count (before the STRING TERMINATOR or another Sixel Command), the repeat count is ignored. The start of another Sixel Command will cancel a pending repeat count.

Format:

```
!      Pn1      <sixel-column-code-to-be-repeated>
2/1      (3/15 - 7/14)
```

Where:

Pn1 repeat count

### 8.1.2 Set Raster Attributes

The Set Raster Attributes command defines raster attributes for all of the following data within a sixel string. This command must precede any Sixel, or any sixel positioning command within a single sixel control string or the command will be ignored.

Format:

```
"      Pn1 ; Pn2 ; Pn3 ; Pn4
2/2
```

Where:

```
Pn1 Pixel aspect ratio numerator
Pn2 Pixel aspect ratio denominator
Pn3 Horizontal Extent
Pn4 Vertical Extent
```

The first two parameters of the Set Raster Attributes command (Pn1 and Pn2) specify the Pixel Aspect Ratio. This ratio defines the shape of the pixel needed to reproduce the picture without distortion. The ratio is defined by two numbers, a numerator and a denominator, and is the ratio of the vertical to the horizontal shape of the pixel.

For example, if a pixel were to be half as wide as tall, the pixel aspect ratio would be 2:1, or 200:100. The Pixel Aspect Ratio times the horizontal grid size yields the vertical grid size.

The third parameter of the Set Raster Attributes command (Pn3) specifies the Horizontal Extent, the horizontal size in pixels of the intended image defined by the picture data.

This parameter allows trailing background Sixel data to be omitted from the picture definition and still allow for color background, and to provide a summary to avoid a complete scanning of the data for the horizontal limits.

This parameter does not limit the number of pixels a device may image. In the case of receiving more pixels than the extent defines, they will be imaged normally. Thus, the receiving device will NOT clip the image to the horizontal extent. Conforming software will not transmit Sixel data which extends beyond the specified horizontal extent.

The fourth parameter of the Set Raster Attributes command (Pn4) specifies the Vertical Extent, the vertical size in pixels of the intended image defined by the picture data. This parameter has the same functionality vertically as the horizontal extent has horizontally. The receiving device will NOT clip the image to the vertical extent. Conforming software will not transmit Sixel data which extends beyond the specified vertical extent.

Conforming software shall specify all parameters explicitly. Guideline: omitted parameters for Pn1 and Pn2 may be interpreted as '0' (zero) and default to '1' (one). ";0 may be interpreted as "1;1 for example.

### 8.1.3 Color Introducer

The Color Introducer Command starts a color selection sequence. It is followed by a color number and optional additional parameters. The color number always specifies the color number with which following Sixel data will be presented.

Format:

```
#   Pc ; Pu ; Px ; Py ; Pz
2/3   \_____/
        optional parameters
```

Where:

```
Pc  color number
Pu  color coordinate system
Px  Hue angle, or Red RGB coordinate
Py  Lightness, or Green RGB coordinate
Pz  Saturation, or Blue RGB coordinate
```

If a color identifier appears in the data stream with no additional parameters, it merely selects the color for following Sixel data. If followed by additional parameters, the color specifier represents a new definition for the color number. The parameters select a color in a universal color coordinate system as follows:

Pc is the color number, 0 to 255 (or larger device limit).

Pu is the universal coordinate system:

```
0 - illegal
1 - HLS (hue/lightness/saturation)
2 - RGB (red/green/blue)
```

Px, Py, Pz are the color coordinates in the specified system:

|    | HLS                | RGB          |
|----|--------------------|--------------|
| Px | Hue angle, 0-360.  | Red, 0-100.  |
| Py | Lightness, 0-100.  | Green, 0-100 |
| Pz | Saturation, 0-100. | Blue, 0-100. |

Values for Pu, Px, Py, and Pz other than those specified above cause the entire color specifier command to be ignored, including the color select parameter, Pc. Conforming software shall specify all parameters to be interpreted explicitly. If optional parameters are included to define a new color, they should all be specified. Guideline: omitted parameters for Px, Py, and Pz may be interpreted as '0' (zero); parameter value '0' (zero) for Pu will cause the entire command to be ignored.

Devices must implement color numbers 0 to 255. Devices may implement color numbers larger than 255. Conforming software will use only numbers less than 255, and will use color numbers in sequence starting from 0. In the case of an index which exceeds the

bounds of the device, the unimplemented index must be mapped back into the supported range.

Note this command may load or change the device's color table.

### 8.1.4 Graphics Carriage Return

The Graphics Carriage Return command causes the Sixel active position to move to the graphic left margin. This Sixel control code is the only code which allows rewriting of a Sixel position and thus is required for writing more than a single color into a Sixel position.

Format:

\$  
2/4

(Graphics Carriage Return does not accept any parameters)

### 8.1.5 Graphics Next Line

The Graphics Next Line command causes the Sixel active position to move to the graphic left margin and down one row of sixels (six actual grid units).

Format:

-  
2/13

(Graphics Next Line does not accept any parameters)

## 8.2 SIXEL DATA

Sixel Data is used to represent the pixels of the raster image in columns of six pixels per character.

Sixel data is coded as graphic characters in the range 3/15 to 7/14. The six pixels to image are derived by subtracting the offset (63 decimal) from the code and assigning each of the low order 6 bits to a grid position. The six pixels are arranged vertically as follows:

|              |             |
|--------------|-------------|
| Top pixel    | Bit 0 (LSB) |
|              | Bit 1       |
|              | Bit 2       |
|              | Bit 3       |
|              | Bit 4       |
| Bottom pixel | Bit 5 (MSB) |

For example, if the character code 4/1 (ASCII A) is received, the offset value (63 decimal) is subtracted from the code value (65 decimal). The resulting value of 2 is mapped into the horizontal scan as follows:

|            |   |   |   |   |   |   |
|------------|---|---|---|---|---|---|
| Data Bits: | 5 | 4 | 3 | 2 | 1 | 0 |
| 2 =        | 0 | 0 | 0 | 0 | 1 | 0 |

```

Scan:  (top)  1  o
          2  x
          3  o
          4  o
          5  o
(bottom)  6  o

```

where "o" indicates the the pixel spot is not printed and "x" indicates that the pixel spot is printed.

### 8.2.1 Sixel Column Codes

| Character   | ?   | @   | A   | B   | C   | D   | E   | F   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 077 | 100 | 101 | 102 | 103 | 104 | 105 | 106 |
| Decimal     | 63  | 64  | 65  | 66  | 67  | 68  | 69  | 70  |
| Hexadecimal | 3F  | 40  | 41  | 42  | 43  | 44  | 45  | 46  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |

| Character   | G   | H   | I   | J   | K   | L   | M   | N   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 107 | 110 | 111 | 112 | 113 | 114 | 115 | 116 |
| Decimal     | 71  | 72  | 73  | 74  | 75  | 76  | 77  | 78  |
| Hexadecimal | 47  | 48  | 49  | 4A  | 4B  | 4C  | 4D  | 4E  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |

| Character   | O   | P   | Q   | R   | S   | T   | U   | V   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 117 | 120 | 121 | 122 | 123 | 124 | 125 | 126 |
| Decimal     | 79  | 80  | 81  | 82  | 83  | 84  | 85  | 86  |
| Hexadecimal | 4F  | 51  | 51  | 52  | 53  | 54  | 55  | 56  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |

| Character   | W   | X   | Y   | Z   | [   | \   | ]   | ^   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 127 | 130 | 131 | 132 | 133 | 134 | 135 | 136 |
| Decimal     | 87  | 88  | 89  | 90  | 91  | 92  | 93  | 94  |
| Hexadecimal | 57  | 58  | 59  | 5A  | 5B  | 5C  | 5D  | 5E  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |

| Character   | _   | `   | a   | b   | c   | d   | e   | f   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 137 | 140 | 141 | 142 | 143 | 144 | 145 | 146 |
| Decimal     | 95  | 96  | 97  | 98  | 99  | 100 | 101 | 102 |
| Hexadecimal | 5F  | 60  | 61  | 62  | 63  | 64  | 65  | 66  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |

| Character   | g   | h   | i   | j   | k   | l   | m   | n   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 147 | 150 | 151 | 152 | 153 | 154 | 155 | 156 |
| Decimal     | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| Hexadecimal | 67  | 68  | 69  | 6A  | 6B  | 6C  | 6D  | 6E  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |

| Character   | o   | p   | q   | r   | s   | t   | u   | v   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 157 | 160 | 161 | 162 | 163 | 164 | 165 | 166 |
| Decimal     | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 |
| Hexadecimal | 6F  | 70  | 71  | 72  | 73  | 74  | 75  | 76  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | o   | o   | o   | o   | o   | o   | o   | o   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |

| Character   | w   | x   | y   | z   | {   |     | }   | ~   |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Octal       | 167 | 170 | 171 | 172 | 173 | 174 | 175 | 176 |
| Decimal     | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 |
| Hexadecimal | 77  | 78  | 79  | 7A  | 7B  | 7C  | 7D  | 7E  |
| Dot Pattern | o   | x   | o   | x   | o   | x   | o   | x   |
|             | o   | o   | x   | x   | o   | o   | x   | x   |
|             | o   | o   | o   | o   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |
|             | x   | x   | x   | x   | x   | x   | x   | x   |

## 9 CODING ISSUES

### 9.1 C0 CODES

The inclusion of C0 Controls 0/8 to 0/13 in control string data is intended for convenience in formatting and storing control strings. These codes shall have no effect on the interpretation of Sixel Control strings.

Codes in the range 0/0 through 0/7 and 0/14 through 1/15 are considered errors. The communications control characters, XON (DC1) and XOFF (DC3) are handled at a different level. Cancel (CAN), Substitute (SUB), Escape (ESC), Bell (BEL), and Enquire (ENQ) are treated as follows:

1. CAN - exit DCS mode processing, exit Sixel mode.
2. SUB - process as if a 3/15 code (blank Sixel) was received - this is to limit the affect of some communication line errors.
3. ESC - exit DCS mode processing, exit Sixel mode, begin processing escape sequence.
4. BEL - same action as in text mode.
5. ENQ - same action as in text mode.

All other C0 Codes are ignored.

### 9.2 GL CODES

Codes in the range 2/0 through 7/15 are treated as follows:

|               |                |
|---------------|----------------|
| 2/0 (SPACE)   | Ignored        |
| 2/1 - 3/14    | Sixel Commands |
| 3/15 - 7/14   | Sixel Data     |
| 7/15 (DELETE) | Ignored        |

### 9.3 C1 CODES

Codes in the range 8/0 through 9/15 exit DCS mode processing, exit Sixel mode, and the C1 control code is processed outside of the Sixel mode.

## 9.4 GR CODES

Codes in range 10/0 through 15/15 are errors. The 8th bit is set to zero and the code is then processed as a GL code. Conforming software shall not transmit GR codes.

## 10 INITIAL STATES

No Sixel state is preserved from one entering of Sixel mode to the next. All Sixel state is reset when the Sixel mode is entered.

The following states are initialized when Sixel mode is entered:

|                    |                                                                         |
|--------------------|-------------------------------------------------------------------------|
| Background color:  | Device default background.                                              |
| Sixel color:       | Contrasting to background.                                              |
| Color numbers:     | All unspecified color numbers image as the default Sixel color.         |
| Horizontal extent: | Distance from current ANSI text position to current ANSI right margin.  |
| Vertical extent:   | Distance from current ANSI text position to current ANSI bottom margin. |

Note that the raster attributes (horizontal grid size, pixel aspect ratio) are initialized by the Macro Parameter, even if unspecified and defaulted to zero.

Conforming software will always initialize the horizontal and vertical extent. Conforming software will also initialize any color numbers used in the picture definition.

## 11 ANSI TEXT INTERACTIONS

The Sixel protocol has certain interactions with the ANSI text portion of the device. Portions of the ANSI text state affect Sixel printing when Sixel mode is entered, and the results of Sixel printing affect portions of the ANSI text state when Sixel mode is exited. The majority of interaction is in the area of active position, although margins are also involved.

### 11.1 ENTERING SIXEL MODE

The Sixel active position is set equal to the ANSI text active position when Sixel mode is entered. The center of the top dot is printed 70 decipoints (.0972 inch) above the character baseline for compatibility with devices which use cell positioning. (Explanatory note: 70 decipoints is consistent with the standard spacing of multi-wire print heads.) The horizontal and vertical axes are established as the same as the ANSI horizontal and vertical axes. No other information is carried from the ANSI text state; in particular, the ANSI SGR (Select Graphic Rendition) selections DO NOT affect sixels.

### 11.2 WHILE IN SIXEL MODE

### 11.2.1 Printing at The Active Position

Sixels are printed relative to the active position such that the top pixel of the Sixel is placed at the current horizontal position and seven actual grid vertical sizes above the current vertical position.

#### GUIDELINE:

**On devices with significantly higher resolution than the vertical grid size, sixels should be processed the same as a font with an above baseline of 70 decipoints, and a below baseline of  $6 \times (\text{vertical grid}) - 70$  decipoints. If the first character flag is set when printing sixels, the Active Position will first be moved down by 70 decipoints (the above baseline amount). If the Active Position is closer to the Bottom Margin than the below baseline value, a wrap condition will occur. Graphic new line will act like a LF of  $6 \times (\text{vertical grid})$ , and wrap at the page end position.**

### 11.2.2 Right Margin

Sixels defined to be printed past the right margin are not printed.

### 11.2.3 Top Margin

If the Sixel active position is such that printing would occur above the top margin, then that part of Sixel will image above the top margin.

### 11.2.4 Bottom Margin

Advancing the Sixel active position past the bottom margin has an effect similar to that of ANSI text. In video devices, advancing past the bottom margin will cause scrolling to occur (if text drawn into this region would have scrolled). In printers, the action will also be similar to that of text causing the active position to advance to the next page consistent with the setting of Form Mode and other parameters (normal Sixel row vertical spacing can be maintained on continuous form machines).

## 11.3 EXITING SIXEL MODE

The Horizontal Active position of the ANSI text is not affected by Sixel mode and set exactly to what it was when Sixel mode was entered.

The vertical active position of the ANSI text is affected by Sixel mode. The ANSI text vertical position is updated to reflect the vertical motion commands executed in the Sixel printing. Note that on line oriented devices, this may leave the ANSI text active position with a non integer line value, only getting back on line boundaries after an absolute vertical position command. Also, the vertical positioning commands of Sixel mode use the ACTUAL grid size, which may be different than the specified grid size. Therefore, software doing pagination should issue an absolute position command before placing characters to insure placement as expected.

Some devices may require re-alignment to a grid established for ANSI text after leaving Sixel mode. In this case, an adjustment less than one character height may occur in a downward direction. Conforming software will not assume any exact alignment of the ANSI text vertical position following a Sixel image.

## 12 FALLBACK

As noted in the introduction, this protocol is quite flexible in the range of imaging formats provided. It is recognized that few (if any) devices will be able to faithfully image all of the rasters defined by the protocol. The purpose of this section is to specify fallback and best fit algorithms and techniques.

The commands allowing fallback are the interpretation of Pixel aspect ratio, Horizontal grid size, and color selection.

A device may require that the grid size used for imaging the raster be different than that specified by the Pixel aspect ratio and horizontal grid size. In such a case, the grid size used for imaging the raster is called the "actual grid size". Note that several commands use this actual grid size specifically, not the ideal grid size specified. Conforming devices must clearly state in their product documentation how grid sizes fall back.

The general rule for grid size fall back is that a device selects an actual grid size that will come closest to but does not exceed the specified grid size, but never less than the smallest imageable unit of the device. (That is, if the smallest size that a device can print is larger than the specified grid size, the device prints it anyway, using the smallest unit as the actual grid).

Since some devices may have high frequency grid size errors that do not accumulate, the average grid size over not more than 30 pixels is used to determine the actual grid size. These non-accumulative errors may be due to devices mechanics (two different resolution mechanism working together like a print head and a paper motor), or due to implementation of a scaling algorithm that combines a non-integer number of pixels into an integer number of device print units.

The pixel aspect ratio should be preserved if possible.

### GUIDELINE:

**Many common grid size specifications were intended for devices with coordinate units based on 1/72" (equal to 1 point or 10 decipoints). When converting to 150/300/600 dpi devices, the proper fallback is to use 1/75" for each decipoint instead of 1/72". This results in a slightly smaller image (4%), but avoids pixel interference patterns from attempting to scale to a non integral number of device pixels.**

There are two classes of color fallback - black and white (monochrome), and limited true color.

For monochrome devices, there are several levels of fallback that are device dependent. The most common and the least that conforming devices must do is to write all the one bits in the only color available and not write the 0 bits. Another fallback would be to texture or halftone each pixel, or even texture or halftone an area of pixels.

For color devices that can not image all the colors possible, mapping of the color definitions to the device set is acceptable. The following eight-color mapping shall be used for eight color devices using a subtractive color process.

## HLS Coordinate System

-----

| Hue Angle | Intended HLS Color | Fallback Color         |
|-----------|--------------------|------------------------|
| 31 - 90   | Magenta            | Magenta                |
| 91 - 150  | Red                | Red (Yellow + Magenta) |
| 151 - 210 | Yellow             | Yellow                 |
| 211 - 270 | Green              | Green (Yellow + Cyan)  |
| 271 - 330 | Cyan               | Cyan                   |
| 331 - 30  | Blue               | Blue (Magenta + Cyan)  |

## Lightness

|            |                                  |
|------------|----------------------------------|
| 0% - 14%   | Disregard hue angle, print black |
| 15% - 85%  | Print based on hue angle         |
| 86% - 100% | Disable Printing (White)         |

Saturation is ignored, assumed to be 100%

## RGB Coordinate System

-----

| Red   | Green | Blue  | Intended Color | Fallback Colors             |
|-------|-------|-------|----------------|-----------------------------|
| 0     | 0     | 0     | Black          | Black (Yellow+Magenta+Cyan) |
| 1-100 | 0     | 0     | Red            | Red (Yellow + Magenta)      |
| 0     | 1-100 | 0     | Green          | Green (Yellow + Cyan)       |
| 1-100 | 1-100 | 0     | Yellow         | Yellow                      |
| 0     | 0     | 1-100 | Blue           | Blue (Magenta + Cyan)       |
| 1-100 | 0     | 1-100 | Magenta        | Magenta                     |
| 0     | 1-100 | 1-100 | Cyan           | Cyan                        |
| 1-100 | 1-100 | 1-100 | White          | (None)                      |

0 = selected color is not used  
 1-100 = selected color is used

## 12.1 DEVIATIONS

### 12.1.1 VT125

1. Initialization - The VT125 does not reset the Sixel writing color to contrast to the background.
2. Relation to ANSI text position - The VT125 does not start the Sixel position at the ANSI text position but rather at the upper left corner of the display. It does not update the ANSI text vertical position at the termination of a Sixel image.
3. Color numbers - The VT125 accepts color numbers 0, 1, 2, 3 but does not allow color specifiers.
4. Background select - The VT125 does not accept this parameter. It always uses the background color for unwritten sixels by erasing the screen to background (i.e. extent is the entire screen).
5. Scrolling - The VT125 does not scroll when the bottom margin is reached.

6. Raster attributes - The only raster attributes accepted by the VT125 is defined by Macro Parameter value of 1. Thus all other combinations of raster attributes fall back to this selection.

### 12.1.2 VT240

1. Initialization - The VT240 does not reset the Sixel writing color to contrast to the background. It retains the colors from the previous Sixel transmission.
2. Relation to ANSI text position - The VT240 does not start the Sixel position at the ANSI text position but rather at the upper left corner of the display. It does not update the ANSI text vertical position at the termination of a Sixel image.
3. Horizontal and Vertical Extent - The VT240 assumes that the extent of the image is the entire screen when Background Select is specified to fill in the background; thus the VT240 erases the screen to background in this case.
4. Scrolling - The VT240 does not scroll when the bottom margin is reached.
5. Raster attributes - The only raster attributes accepted by the VT240 is defined by Macro Parameter value of 1. Thus all other combinations of raster attributes fall back to this selection.
6. Horizontal Grid Size parameter - The VT240 interprets this parameter as a different function. The effect of specifying this parameter has very limited effects.

### 12.1.3 LA50

1. The LA50 has a hardware switch to select between 2:1 and 2.5:1 pixel aspect ratios. 2:1 is required for Level 1 conformance.

### 12.1.4 LA100 and LA210

1. The LA100 and LA210 are Level 2 devices (recognize the Macro Parameter), but do not recognize the set raster attributes command.

Guideline: Software that wishes to support these devices explicitly may set the Macro parameter for the desired characteristics, but should also specify the horizontal grid size (Pn3) and raster attributes to over-ride the Macro parameter for use on other Level 2 devices.

## 12.2 CHANGE HISTORY

### 12.2.1 Revision AX11 to AX12

#### General

1. Removed Revision AX11 change bars. Added change bars to any change that could affect conformance or interpretation of the document or should be brought to the attention of terminal implementors or software engineers.
2. Re-organized main body of the standard to combine syntax and semantic information, making it easier for implementors to follow.

#### Terminology Section

3. Removed definition of "Raster Aspect Ratio" since the term is not used anywhere in the chapter.
4. Clarified "Picture Definition" by indicating it consists of Sixel Data and Sixel Commands.
5. Added definition of Grid Size; the distance between two adjacent grid points.
6. Added definition of SIXEL.

### **Macro Parameter**

7. Added sentence: The intended vertical grid size implied by the macro value is always 1/72 of an inch.
8. Changed the pixel aspect ratio for macro value 5 from 183:100 to 200:100. Macro value 5 is intended to give a 200:100 pixel aspect ratio (as on the LN03). 183:100 is the fallback on the LA12/34/100/210.

### **Sixel Commands**

9. Added format descriptions to each Sixel command.
10. Clarified meaning of "ignoring" unrecognized sixel commands to indicate command and parameters must be parsed and ignored.
11. Clarified behavior of Repeat Introducer when sixel column code does not follow immediately. Starting another sixel command will cancel a pending repeat count.
12. Added material on Set Raster Attributes Command:

"Conforming software shall specify all parameters explicitly. Guideline: omitted parameters for Pn1 and Pn2 may be interpreted as '0' (zero) and default to '1' (one)."

Clarified that the Set Raster Attributes command must precede any sixel, or any sixel positioning command within a single sixel string or the command will be ignored.

13. Added material on Color Introducer command:

"Conforming software shall specify all parameters to be interpreted explicitly. If optional parameters are included to define a new color, they should all be specified. Guideline: omitted parameters for Px, Py, and Pz may be interpreted as '0' (zero); parameter value '0' (zero) for Pu will cause the entire command to be ignored.

"In the case of an index which exceeds the bounds of the device, the unimplemented index must be mapped back into the supported range."

"Note this command may load or change a device's color table."

### **ANSI Text Interactions**

14. Clarified that the ANSI text active position is not changed when Sixel mode is entered. The center of the top dot is printed 70 decipoints above the active position. (Explanatory note: 70 decipoints is consistent with the standard spacing of multi-wire print heads.)

15. Added guideline on printing at the active position for devices with significantly higher resolution than the vertical grid size.
16. Simplified section on Bottom Margin by emphasizing that sixels should be treated the same as text, and removing duplicate material from the PSRM positioning controls chapter.

#### **Other**

17. Added an example of a complete Sixel Control String.
18. Corrected list item numbers (1-3) which were confused with Background Select parameter values (0-2).
19. Removed SPACE (2/0) from the set of sixel control codes. Added statement SPACE shall be ignored in sixel control strings.
20. Added paragraph stating that format effectors (0/8 - 0/13) shall not effect the interpretation of sixel control strings.
21. Added paragraph to Coding section describing how GL codes are handled to make it inclusive of all 8-bit codes. SPACE (2/0) and DELETE (7/15) shall be ignored.
22. Added statement that: Conforming software shall not transmit GR codes.
23. Added table of Sixel column codes.
24. Clarified software conformance requirement for initialization. Conforming software will always initialize the horizontal and vertical extent (not just if used in the picture definition as stated for color numbers).
25. Added statement to fallback section that: Conforming devices must clearly state in their product documentation how grid sizes fall back.
26. Added guideline on fallback for 150/300/600 dpi devices.
27. Fixed legend on RGB fallback table to indicate '0' means selected color is NOT used.
28. Added LA50 to deviations section.
29. Added LA100 and LA210 to deviations section. Included guideline on use of the Macro parameter.

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